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MFN 09-292

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**Subject: Response to Portion of NRC Request for Additional Information
Letter No. 329 Related to ESBWR Design Certification Application
– Site Characteristics - RAI Number 2.5-10 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) responses to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAIs) sent by NRC letter No. 329, dated April 8, 2009 (Reference 1).

GEH response to RAI 2.5-10 S01 is provided in Enclosure 1. Enclosure 2 provides any affected DCD Sections.

Sincerely,

A handwritten signature in black ink that reads "Richard E. Kingston".

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. MFN 09-250 - Letter from U.S. Nuclear Regulatory Commission to Mr. Jerald G. Head, GEH, *Request For Additional Information Letter No. 329 Related To ESBWR Design Certification Application*, dated April 8, 2009

Enclosure:

1. MFN 09-292 -Response to NRC Request for Additional Information Letter No. 329 Related to ESBWR Design Certification Application – DCD Tier 2 Chapter 2 - Site Characteristics - RAI Number 2.5-10 S01
2. MFN 09-292 -Response to NRC Request for Additional Information Letter No. 329 Related to ESBWR Design Certification Application – DCD Tier 2 Chapter 2 – Site Characteristics - RAI Number 2.5-10 S01 DCD Markups.

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EDRF Section 0000-0101-1812 (RAI 2.5-10 S01)

ENCLOSURE 1

MFN 09-292

**Response to NRC RAI Letter No. 329
Related to ESBWR Design Certification Application¹**

DCD Tier 2 Chapter 2 – Site Characteristics

RAI Number 2.5-10 S01

¹ Original Response previously submitted under MFN 09-083 without attachments is included to provide historical continuity during review.

NRC RAI 2.5-10

In ESBWR DCD Revision 5, the minimum shear wave velocity was defined in site parameter Table 5.1-1 (Tier 1 of ESBWR DCD) and Table 2.0-1 (Tier 2 of ESBWR DCD) as 300 m/s (1000 ft/s). In the footnote, however, minimum shear wave velocity was further clarified as equivalent uniform shear wave velocity (V_{eq}) over the entire soil column at seismic strain. V_{eq} can be calculated over the depth equal to the embedment depth plus 2 times the largest foundation plan dimension below the foundation,

$$V_{eq} = \frac{\sum d_i}{\sum \frac{d_i}{V_i}}$$

where d_i and V_i are the depth and shear wave velocity, respectively, of the i th layer. In addition, the ratio of the largest to the smallest shear wave velocity over the mat foundation width at the foundation level does not exceed 1.7.

This ESBWR DCD definition allows shear wave velocity averaged over the depth (embedment depth + 2 times of the largest foundation plan dimension) below the foundation. Based on this averaging, the shear wave velocity at around the foundation depth can be extremely low because a deeper hard rock layer with a large shear wave velocity can lift the average above 1000 ft/s for the soil column under consideration. In addition, “the ratio of the largest to the smallest shear wave velocity over the mat foundation width at the foundation level does not exceed 1.7” did not provide any constraint on the minimum shear wave velocity on the profile because the ratio is evaluated “over the mat foundation width at the foundation level.” This definition deviates from the staff’s position indicated in SRP 3.7.1. SRP 3.7.1 specifies that the soils immediately below the foundation have a shear wave velocity of at least 1000 fps. If the minimum shear wave velocity of the supporting foundation material is less than 1,000 ft/s, additional studies need to be performed which consider the average shear wave velocity, and its degree of variability addressing potential impact on soil-structure interaction, potential settlements and design of foundation elements.

Please justify your definition for V_{eq} and comment on the potential for low velocity material and its implications for settlement, soil response and foundation design. Also, clarify if the ratio of 1.7 between the largest and smallest shear wave velocity is intended to constrain soil horizontal heterogeneity. If not, explain where the ratio 1.7 came from and why it was defined over the mat foundation width and at the foundation level.

GEH Response

The first two sentences of DCD Tier 1 Table 5.1-1, Note (3) and DCD Tier 2 Table 2.0-1, Note (8) will be revised in Revision 6 to read, “This is the minimum shear wave velocity, associated with seismic strains for lower bound soil properties after taking into account uncertainties, at the foundation level.”

The DCD Revision 6 markup of DCD Tier 2 Table 2.0-1, Note (17), included with GEH's responses to NRC RAI 3.8-94, Supplement 3 and NRC RAI 3.8-96, Supplement 3, will be revised for consistency with the above DCD Tier 1 Table 5.1-1, Note (3) and DCD Tier 2 Table 2.0-1, Note (8) revision. The GEH response to NRC RAI 3.8-94, Supplement 3, transmitted to the NRC on December 9, 2008 via MFN 06-407, Supplement 10, will be revised and transmitted to the NRC to include this revision to the DCD Revision 6 markup of DCD Tier 2 Table 2.0-1, Note (17). The GEH response to NRC RAI 3.8-96, Supplement 3, transmitted to the NRC on December 12, 2008 via MFN 06-407, Supplement 11, will be revised and transmitted to the NRC to include this revision to the DCD Revision 6 markup of DCD Tier 2 Table 2.0-1, Note (17).

For consistency, DCD Tier 1 Table 5.1-1, Note (6) will be added and DCD Tier 2 Subsection 3.7.5 and DCD Tier 2 Table 2.0-1, Note (16) will be revised in Revision 6 to read, "For sites not meeting the soil property requirements, a site-specific analysis is required to demonstrate the adequacy of the standard plant design." In addition, the first sentence of the third paragraph of DCD Tier 1 Section 5.1 will be revised in Revision 6 to read, "In the case of seismic design and soil parameters not meeting the defined conditions, site-specific soil-structure interaction analyses may be performed."

The requirement that the ratio of the largest to the smallest shear wave velocity over the mat foundation width at the foundation level not exceed 1.7 was added to address the effect of *soil horizontal heterogeneity*. Based on analysis results, it was determined that the DCD design envelopes the result of horizontal variations of the soil stiffness as long as the ratio of the largest to the smallest shear wave velocity over the mat foundation width at foundation level does not exceed 1.7. Please refer to GEH's response to NRC RAI 3.8-93, Supplement 2 transmitted to the NRC via MFN 06-407, Supplement 3 on November 28, 2007.

DCD Impact

Markups of DCD Tier 1 Section 5.1, DCD Tier 1 Table 5.1-1, DCD Tier 2 Table 2.0-1 and DCD Tier 2 Subsection 3.7.5 were provided in MFN 09-083, which was transmitted to the NRC on January 30, 2009.

NRC RAI 2.5-10, Supplement 1

In response to RAI 2.5-10, GEH modified the footnote for the Minimum Shear Wave Velocity definition in DCD Tier 1, Revision 5, Table 5.1-1 by removing equivalent uniform shear wave velocity (V_{eq}). The updated footnote states that “this is the minimum shear wave velocity, associated with seismic strains for lower bound soil properties after taking into account uncertainties, at the foundation level.” However, this new footnote only defines the minimum shear wave velocity for the soil at the foundation level, not for the entire soil profile beneath the foundation level. 10 CFR Part 50, Appendix S specifies the minimum safe shutdown earthquake (SSE) at the foundation level; however, the SSE ground motion response spectrum is dependent on soil properties, such as shear wave velocity (V_s), over the entire soil profile and not just at the foundation level. To ensure the static and dynamic stability of the foundation as specified in SRP 2.5.4, justify your specification of the minimum shear wave velocity values only at the foundation level and not for the entire soil profile. In addition, clarify “lower bound soil properties.”

GEH Response

GEH agrees that the minimum shear wave velocity value applies to the supporting foundation material. The phrase “of the supporting foundation material” will replace “at the foundation level”, which was in the DCD markup in GEH’s response to NRC RAI 2.5-10 (MFN 09-083, dated 1/30/09), in DCD Tier 1 Table 5.1-1 Note 3 and DCD Tier 2 Table 2.0-1 Note 8 in Revision 6.

The lower bound soil properties are minus one sigma from the mean. The phrase “at minus one sigma from the mean” will replace “after taking into account uncertainties”, which was in the DCD markup in GEH’s response to NRC RAI 2.5-10 (MFN 09-083, dated 1/30/09), in DCD Tier 1 Table 5.1-1 Note 3 and DCD Tier 2 Table 2.0-1 Note 8 in Revision 6.

DCD Impact

DCD Tier 1 Table 5.1-1 Note 3 and DCD Tier 2 Table 2.0-1 Note 8 are revised in Revision 6 as noted in the attached markups.

MFN 09-292

Enclosure 2

**Response to NRC Request for Additional
Information Letter No. 329 Related to ESBWR
Design Certification Application –
DCD Tier 2 Chapter 2 – Site Characteristics
RAI Number 2.5-10 S01 DCD Markups**

Table 5.1-1
Envelope of ESBWR Standard Plant Site Parameters (continued)

Meteorological Dispersion (X/Q): (continued)	Technical Support Center X/Q:*	
Reactor Building		
0-2 hours:	1.00E-03 s/m ³	1.00E-03 s/m ³
2-8 hours:	6.00E-04 s/m ³	6.00E-04 s/m ³
8-24 hours:	3.00E-04 s/m ³	3.00E-04 s/m ³
1-4 days:	2.00E-04 s/m ³	2.00E-04 s/m ³
4-30 days:	1.00E-04 s/m ³	1.00E-04 s/m ³
Turbine Building		
0-2 hours:	2.00E-03 s/m ³	2.00E-03 s/m ³
2-8 hours:	1.50E-03 s/m ³	1.50E-03 s/m ³
8-24 hours:	8.00E-04 s/m ³	8.00E-04 s/m ³
1-4 days:	6.00E-04 s/m ³	6.00E-04 s/m ³
4-30 days:	5.00E-04 s/m ³	5.00E-04 s/m ³
Passive Containment Cooling System / Reactor Building Roof		
0-2 hours:	2.00E-03 s/m ³	2.00E-03 s/m ³
2-8 hours:	1.10E-03 s/m ³	1.10E-03 s/m ³
8-24 hours:	5.00E-04 s/m ³	5.00E-04 s/m ³
1-4 days:	4.00E-04 s/m ³	4.00E-04 s/m ³
4-30 days:	3.00E-04 s/m ³	3.00E-04 s/m ³

Notes:

- (1) ~~The design of the Radwaste Building uses a set of design parameters that are specified in Regulatory Guide 1.143, Table 2, Class RW IIa instead of the corresponding values given in this table for all parameters except as follows: (1) Tornado: Wind Speeds, Radius, Pressure Drop, and Rate of Pressure Drop; (2) Seismology: Horizontal and Vertical Ground Spectra: See Figures 5.1-1 and 5.1-2.~~ [\(Deleted\)](#)
- (2) At foundation level of Seismic Category I structures. For minimum dynamic bearing capacity site-specific application, use the larger value or a linearly interpolated value of the applicable range of shear wave velocities at the foundation level. The shear wave velocities of soft, medium and hard soils are 300 m/sec (1000 ft/sec), 800 m/sec (2600 ft/sec) and greater than or equal to 1700 m/sec (5600 ft/sec), respectively.
- (3) This is the ~~equivalent uniform minimum~~ shear wave velocity ~~of the supporting foundation material~~ (V_{eq}) over the entire soil column at seismic strain, which is a lower bound value after taking into account uncertainties. ~~V_{eq} is calculated to achieve the same wave traveling time over the depth equal to the embedment depth plus 2 times the largest foundation plan dimension below the foundation as follows:~~ where d_i and V_i are the depth and shear wave velocity, respectively, of the i th layer associated with seismic strains for lower bound soil properties ~~at minus one sigma from the mean.~~ The ratio of the largest to the smallest shear wave velocity over the mat foundation width ~~at of the supporting foundation level material~~ does not exceed 1.7.

$$\frac{V_{eq}}{\sum \frac{d_i}{V_i}}$$

Notes for Table 2.0-1:

- (1) ~~The design of the Radwaste Building uses a set of design parameters that are specified in Regulatory Guide 1.143, Table 2, Class RW IIa instead of the corresponding values given in this table for all parameters except as follows:~~ (1) Tornado: Winds Speeds, Radius, Pressure Drop, and Rate of Pressure Drop; (2) Seismology: Horizontal and Vertical Ground Spectra: See Figures 2.0-1 and 2.0-2.
- (2) Probable maximum flood level (PMF), as defined in Table 1.2-6 of Volume III of Reference 2.0-4.
- (3) Maximum speed selected is based on Attachment 1 of Reference 2.0-5, which summarizes the NRC Interim Position on Regulatory Guide 1.76. Concrete structures designed to resist Spectrum I missiles of SRP 3.5.1.4, Rev. 2, also resist missiles postulated in Regulatory Guide 1.76, Revision 1.
- (4) Based on probable maximum precipitation (PMP) for one hour over 2.6 km² (one square mile) with a ratio of 5 minutes to one hour PMP of 0.32 as found in Reference 2.0-3. Roof scuppers and drains are designed independently to limit water accumulation on the roof to no more than an average depth of 100 mm (4 in) during PMP conditions. See also Table 3G.1-2.
- (5) Maximum design roof load accommodates snow load and 48-hour probable maximum winter precipitation (PMWP) in References 2.0-2 and 2.0-6. Roof scuppers and drains are designed independently to limit water accumulation on the roof to no more than an average depth of 100 mm (4 in) during PMWP conditions. See also Table 3G.1-2.
- (6) Zero percent exceedance values are based on conservative estimates of historical high and low values for potential sites. Consistent with Reference 2.0-4, they represent historical limits excluding peaks of less than two hours. One and two percent annual exceedance values were selected in order to bound the values presented in Reference 2.0-4 and available Early Site Permit applications.
- (7) At foundation level of Seismic Category I structures. For minimum dynamic bearing capacity site-specific application, use the larger value or a linearly interpolated value of the applicable range of shear wave velocities at the foundation level. The shear wave velocities of soft, medium and hard soils are 300 m/sec (1000 ft/sec), 800 m/sec (2600 ft/sec) and greater than or equal to 1700 m/sec (5600 ft/sec), respectively.
- (8) This is the ~~equivalent uniform minimum~~ shear wave velocity ~~of the supporting foundation material associated with seismic strains for lower bound soil properties at minus one sigma from the mean (V_{eq}) over the entire soil column at seismic strain, which is a lower bound value after taking into account uncertainties. V_{eq} is calculated to achieve the same wave traveling time over the depth equal to the embedment depth plus 2 times the largest foundation plan dimension below the foundation as follows:~~
$$V_{eq} = \frac{\sum d_i}{\sum \frac{d_i}{V_i}}$$

~~where d_i and V_i are the depth and shear wave velocity, respectively, of the i th layer. The~~

ratio of the largest to the smallest shear wave velocity over the mat foundation width ~~at of~~
the ~~supporting~~ foundation ~~level material~~ does not exceed 1.7.

- (9) Safe Shutdown Earthquake (SSE) design ground response spectra of 5% damping, also termed Certified Seismic Design Response Spectra (CSDRS), are defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Reactor/Fuel and Control Building structures. ~~For ground surface founded Firewater Service Complex structures, the CSDRS is 1.35 times the values shown in Figures 2.0-1 and 2.0-2. For the Firewater Service Complex, which is essentially a surface founded structure, the CSDRS is 1.35 times the values shown in Figures 2.0-1 and 2.0-2 and is defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Firewater Service Complex structure.~~
- (10) Values reported here are actually design criteria rather than site design parameters. They are included here because they do not appear elsewhere in the DCD.
- (11) If a selected site has a X/Q value that exceeds the ESBWR reference site value, the COL applicant will address how the radiological consequences associated with the controlling design basis accident continue to meet the dose reference values provided in 10 CFR ~~50.34~~52.79(a)(1)(vi) and control room operator dose limits provided in General Design Criterion 19 using site-specific X/Q values.
- (12) If a selected site has X/Q values that exceed the ESBWR reference site values, the release concentrations in Table 12.2-17 would be adjusted proportionate to the change in X/Q values using the stack release information in Table 12.2-16. In addition, for a site selected that exceeds the bounding X/Q or D/Q values, the COL applicant will address how the resulting annual average doses (Table 12.2-18b) continue to meet the dose reference values provided in 10 CFR 50 Appendix I using site-specific X/Q and D/Q values.
- (13) Value was selected to comply with expected requirements of southeastern coastal locations.
- (14) Localized liquefaction potential under other than Seismic Category I structures is addressed per SRP 2.5.4 in Table 2.0-2.
- (15) Settlement values are long-term (post-construction) values except for differential settlement within the foundation mat. The design of the foundation mat accommodates immediate and long-term (post-construction) differential settlements after the installation of the basemat.
- (16) For sites not meeting the soil property requirements, a site-specific analysis is required to demonstrate the adequacy of the standard plant design.
- (17) Adjacent layers are the two layers with a total depth of 40 m (131 ft) or 60 m (197 ft) below grade. They correspond to the top and middle layers shown in Table 3A.3-3 for layered site cases 2 and 4. The first layer, termed top layer, covers the top 20 m (66 ft). The second layer, termed bottom layer, covers the next 20 m (66 ft) or 40 m (131 ft). The ratio is the average velocity of the bottom layer divided by the average velocity of the top layer. Either the lower bound seismic strain (i.e., strain compatible) profile or the best estimate low strain profile can be used because only the velocity ratio is of interest. This velocity ratio condition does not apply to the FWSC nor to the RB/FB and CB if founded on rock-like material having a shear wave velocity of 1067 m/sec (3500 ft/sec) or higher.